Claims:

1. A system for detecting the possibility of disease in one of a first body part and a second substantially similar body part by impedance measurements, the system comprising:

a) a main module for controlling the operation of the system;

b) a front-end module connected to the main module and at least one of the first and second body parts for injecting stimulus currents into the at least one of the first and second body parts and receiving voltages generated by the at least one of the first and second body parts in response to the stimulus currents; and,

c) an impedance module connected to the main module and the front-end module for creating the stimulus currents and determining the impedance of the at least one of the first and second body parts based on the received voltages, wherein the stimulus currents comprise a current signal and a complementary current signal thereby forming a differential current signal.

2. A system as claimed in claim 1, wherein the impedance module comprises a current generator for generating the stimulus currents, the current generator comprising:

a) a first current generation module for generating an internal current signal;

b) a first output impedance unit connected to the first current generation module for generating the current signal based on the internal current signal;

c) a second current generation module connected to the first current generation module for generating an internal complementary current signal; and,

d) a second output impedance unit connected to the second current generation module for generating the complementary current signal based on the internal complementary current signal.

3. A system as claimed in claim 2, wherein the current generator further comprises:

a) a first current shield generator for generating a current shield signal related to the current signal; and,

b) a second current shield generator for generating a complementary current shield signal related to the complementary current signal;

wherein, the current shield signal and complementary current shield signals are provided to the front-end module to shield the current signal and complementary current signal from noise.

4. A system as claimed in claim 3, wherein the first current shield generator includes an amplifier having a gain factor for amplifying the current signal to generate the current shield signal, the gain factor being chosen to provide a negative capacitance.

5. A system as claimed in claim 3, wherein the second current shield generator includes an amplifier having a gain factor for amplifying the complementary current signal to generate the complementary current shield signal, the gain factor being chosen to provide a negative capacitance.

6. A system as claimed in claim 2, wherein the impedance module further comprises:

a) a processing unit for creating a current control voltage signal for controlling parameters related to the stimulus currents; and,

b) a digital-to-analog converter connected to the processing unit for receiving the current control voltage signal and generating an analog current control voltage signal;

wherein, the current generator further comprises:

c) a single-ended differential conversion unit connected to the digital-to-analog converter and the first current generation module for converting the analog current control voltage signal to a differential current control voltage signal.

7. A system as claimed in claim 6, wherein one of the parameters is frequency and the frequency of the generated stimulus currents is given by $F_n=F_1*K^n$ where K is a constant and n is an integer greater than or equal to 2.

8. A system as claimed in claim 6, wherein the first current generation module comprises a first gain stage comprising:

a) an amplification stage for amplifying the differential current control voltage signal and converting the amplified differential current control voltage signal to a single-ended amplified current control voltage signal;

b) a filter stage connected to the amplification stage for filtering noise in the single-ended amplified current control voltage signal; and,

c) a feedback stage connected to the amplification stage and the filter stage for feeding back an integrated version of the filtered single-ended amplified current control voltage signal to ensure that the single-ended amplified current control voltage is centered about ground.

9. A system as claimed in claim 8, wherein the first current generation module further comprises a current generation stage connected to the first gain stage for creating the internal current signal, the current generation stage comprising:

a) a second amplification stage for amplifying a difference between the filtered single-ended amplified current control voltage and an integrated version of the internal current signal to generate the internal current signal; and,

b) a second feedback stage connected to the second amplification stage for providing the integrated version of the internal current signal thereto, the second feedback stage comprising:

i) a voltage follower connected to the second amplification stage for following the output of the second amplification stage; and,

ii) an integrator connected to the voltage follower and the second amplification stage for integrating the output

of the voltage follower and providing the integrated output to the second amplification stage, the integrated output being the integrated version of the internal current signal.

10. A system as claimed in claim 6, wherein the second current generation module comprises:

a) a phase adjusting stage for receiving the internal current signal and generating a phase-adjusted internal current signal; and,

b) an inverting stage connected to the phase adjusting stage for inverting the phase-adjusted internal current signal to create the internal complementary current signal.

11. A system as claimed in claim 1, wherein the impedance module comprises:

a) a signal conditioning unit for pre-processing the received voltages to produce a single-ended processed measured voltage, the received voltages forming a differential signal and including a first measured voltage signal and a second measured voltage signal; and,

b) a programmable gain unit connected to the signal conditioning unit for providing a plurality of gain levels to the single-ended processed measured voltage to generate a single-ended amplified measured voltage, the gain levels being defined according to $G_n=G_1*K^n$ where K is a constant and n is an integer greater than or equal to 2.

12. A system as claimed in claim 11, wherein the signal conditioning unit further comprises

a) a first voltage shield generator for generating a first voltage shield signal related to the first measured voltage signal; and,

b) a second voltage shield generator for generating a second voltage shield signal related to the second measured voltage signal;

wherein, the first and second voltage shield signals are provided to the front-end module to shield the first and second measured voltage signals from noise.

13. A system as claimed in claim 12, wherein the first voltage shield generator includes an amplifier having a gain factor for amplifying the first measured voltage signal to generate the first voltage shield signal, the gain factor being chosen to provide a negative capacitance.

14. A system as claimed in claim 12, wherein the second voltage shield generator includes an amplifier having a gain factor for amplifying the second measured voltage signal to generate the second voltage shield signal, the gain factor being chosen to provide a negative capacitance.

15. A system as claimed in claim 11, wherein the signal conditioning unit comprises:

a) a differential input network including:

i) a first filtering stage for removing noise from the first and second measured voltage signals to generate first filtered measured voltages;

ii) a common-mode rejection stage connected to the first filtering stage for removing high frequency common mode noise to generate second filtered measured voltages; and,

iii) a second filter stage connected to the common-mode rejection stage for removing noise from the second filtered measured voltages;

b) a differential voltage amplifier including:

i) an amplification stage for amplifying a difference between the second filtered measured voltages and generating a single-ended measured voltage signal;

ii) a filter stage connected to the amplification stage for filtering the single-ended measured voltage signal; and,

iii) a feedback stage connected to the amplification stage for providing an integrated version of the single-

ended amplified measured voltage to the amplification stage.

16. A system as claimed in claim 15, wherein the impedance module further comprises:

a) a processing unit for calculating impedance values based on the stimulus currents and a corresponding digitized single-ended measured voltage signal;

b) an analog-to-digital converter connected to the processing unit for converting the single-ended measured voltage signal to create the digitized single-ended measured voltage signal;

and, the programmable gain unit comprises:

c) a programmable gain amplifier including:

i) an amplification stage for amplifying the filtered single-ended measured voltage signal;

ii) a second filter stage connected to the amplification stage for filtering the output of the amplification stage; and,

iii) a variable resistance stage connected to the amplification stage for providing the plurality of gain levels, the variable resistance stage including a multiplexer and a plurality of resistor configurations connected to the output paths of the multiplexer; each resistor configuration being related to each other by the factor K;

d) an output stage connected to the programmable gain amplifier for amplifying and shifting the DC level of the output of the second filter stage to create the single-ended amplified measured voltage.

17. A system as claimed in claim 11, wherein the signal conditioning unit includes a common-mode voltage measurement stage for measuring a common-mode voltage of the received voltages, the impedance module further including a processing unit comprising:

a) a calculator module for calculating impedance values based on the stimulus currents and the received voltages; and,

b) a calibrator module for correcting the calculated impedance values, the calibrator module applying a common-mode calibration step and an impedance calibration step.

18. A system as claimed in claim 17, wherein, for a given calculated impedance value, the common-mode calibration step includes identifying the magnitude and phase of the measured common-mode voltage at a pre-defined measurement frequency and correcting the calculated impedance value by subtracting a weighted version of the measured common-mode voltage from the calculated impedance value, the weight being defined by the amount of common-mode voltage rejection provided by the signal conditioning unit.

19. A system as claimed in claim 17, wherein, for a given calculated impedance value, the common-mode calibration step includes identifying the magnitude and phase of the measured common-mode voltage at a pre-defined measurement frequency and correcting the calculated impedance value by subtracting a common-mode calibration number obtained from a lookup table, the common-mode calibration value being indexed by the magnitude and phase of the measured common-mode voltage.

20. A system as claimed in claim 17, wherein, for a given calculated impedance value, the impedance calibration step includes correcting the calculated impedance value by applying an impedance calibration factor from a calibration table, the impedance calibration factor being indexed by the gain that is applied by the programmable gain unit, the measurement frequency and the magnitude of the calculated impedance value.

21. A system as claimed in claim 20, wherein the impedance calibration factor is also indexed by the phase of the calculated impedance value.

22. A system as claimed in claim 20, wherein the system further includes a calibration board for generating the calibration table, the calibration board including a plurality of calibration resistors and a plurality of calibration capacitors selectively connectable with one another to form a plurality of calibration impedances, wherein the resistance of the plurality of calibration resistors are related to one another according to $R_n=R_1*K^n$ and the capacitance of the calibration capacitors are related to one another according to $C_n=C_1*K^n$ and calibration is performed at calibration frequencies related to one another according to $F_n=F_1*K^n$

23. An impedance module for calculating the impedance of a body part, the impedance module creating stimulus currents for injection into the body part and receiving voltages generated by the body part in response to the stimulus currents, the impedance module comprising:

a) a current generator for generating the stimulus currents, the stimulus currents comprising a current signal and a complementary current signal thereby forming a differential current signal;

b) voltage processing circuitry for pre-processing the received voltages and amplifying the received voltages to generate a measured voltage signal;

c) processing circuitry connected to the current generator and the voltage processing circuitry for directing the operation of the impedance module, the processing circuitry including a processing unit for creating a current control voltage signal for controlling parameters related to the stimulus currents, and for calculating an impedance value based on the stimulus current and the measured voltage signal; and,

d) interface circuitry connected to the current generator, the voltage processing circuitry and the processing circuitry.

24. An impedance module as claimed in claim 23, wherein the current generator comprises:

a) a first current generation module for generating an internal current signal;

b) a first output impedance unit connected to the first current generation module for generating the current signal based on the internal current signal;

c) a second current generation module connected to the first current generation module for generating an internal complementary current signal; and,

d) a second output impedance unit connected to the second current generation module for generating the complementary current signal based on the internal complementary current signal.

25. An impedance module as claimed in claim 24, wherein the current generator further comprises:

a) a first current shield generator for generating a current shield signal related to the current signal; and,

b) a second current shield generator for generating a complementary current shield signal related to the complementary current signal;

whereby, in use, the current shield signal and complementary current shield signals are used to shield the current signal and complementary current signal from noise.

26. An impedance module as claimed in claim 25, wherein the first current shield generator includes an amplifier having a gain factor for amplifying the current signal to generate the current shield signal, the gain factor being chosen to provide a negative capacitance.

27. An impedance module as claimed in claim 25, wherein the second current shield generator includes an amplifier having a gain factor for amplifying the complementary current signal to generate the complementary current shield signal, the gain factor being chosen to provide a negative capacitance.

28. An impedance module as claimed in claim 24, wherein the interface circuitry comprises:

a) a digital-to-analog converter connected to the processing unit for receiving the current control voltage signal and generating an analog current control voltage signal; and,

wherein, the current generator further comprises:

b) a single-ended differential conversion unit connected to the digital-to-analog converter and the first current generation module for converting the analog current control voltage signal to a differential current control voltage signal.

29. An impedance module as claimed in claim 23, wherein one of the parameters is frequency and the frequency of the generated stimulus currents is given by $F_n=F_1*K^n$ where K is a constant and n is an integer greater than or equal to 2.

30. An impedance module as claimed in claim 24, wherein the first current generation module comprises a first gain stage comprising:

a) an amplification stage for amplifying the differential current control voltage signal and converting the amplified differential current control voltage signal to a single-ended amplified current control voltage signal;

b) a filter stage connected to the amplification stage for filtering noise in the single-ended amplified current control voltage signal; and,

c) a feedback stage connected to the amplification stage and the filter stage for feeding back an integrated version of the filtered single-ended amplified current control voltage signal to ensure that the single-ended amplified current control voltage is centered about ground.

31. An impedance module as claimed in claim 30, wherein the first current generation module further comprises a current generation stage connected to the first gain stage for creating the internal current signal, the current generation stage comprising:

a) a second amplification stage for amplifying a difference between the filtered single-ended amplified current control voltage and an integrated version of the internal current signal to generate the internal current signal; and,

b) a second feedback stage connected to the second amplification stage for providing the integrated version of the internal current signal thereto, the second feedback stage comprising:

i) a voltage follower connected to the second amplification stage for following the output of the second amplification stage; and,

ii) an integrator connected to the voltage follower and the second amplification stage for integrating the output of the voltage follower and providing the integrated output to the second amplification stage, the integrated output being the integrated version of the internal current signal.

32. An impedance module as claimed in claim 24, wherein the second current generation module comprises:

a) a phase adjusting stage for receiving the internal current signal and generating a phase-adjusted internal current signal; and,

b) an inverting stage connected to the phase adjusting stage for inverting the phase-adjusted internal current signal to create the internal complementary current signal.

33. An impedance module as claimed in claim 23, wherein the voltage processing circuitry comprises:

a) a signal conditioning unit for pre-processing the received voltages to produce a single-ended processed measured voltage, the received voltages forming a differential signal and including a first measured voltage signal and a second measured voltage signal; and,

b) a programmable gain unit connected to the signal conditioning unit for providing a plurality of gain levels to the single-ended processed measured voltage to generate a single-ended amplified measured

voltage, the gain levels being defined according to $G_n=G_1*K^n$ where K is a constant and n is an integer greater than or equal to 2.

34. An impedance module as claimed in claim 33, wherein the signal conditioning unit comprises:

a) a first voltage shield generator for generating a first voltage shield signal related to the first measured voltage signal; and,

b) a second voltage shield generator for generating a second voltage shield signal related to the second measured voltage signal;

whereby, in use, the first and second voltage shield signals shield the first and second measured voltage signals from noise.

35. An impedance module as claimed in claim 34, wherein the first voltage shield generator includes an amplifier having a gain factor for amplifying the first measured voltage signal to generate the first voltage shield signal, the gain factor being chosen to provide a negative capacitance.

36. An impedance module as claimed in claim 34, wherein the second voltage shield generator includes an amplifier having a gain factor for amplifying the second measured voltage signal to generate the second voltage shield signal, the gain factor being chosen to provide a negative capacitance.

37. An impedance module as claimed in claim 33, wherein the signal conditioning unit comprises:

a) a differential input network including:

i) a first filtering stage for removing noise from the first and second measured voltage signals to generate first filtered measured voltages;

ii) a common-mode rejection stage connected to the first filtering stage for removing high frequency common mode noise to generate second filtered measured voltages; and,

iii) a second filter stage connected to the common-mode rejection stage for removing noise from the second filtered measured voltages;

b) a differential voltage amplifier including:

i) an amplification stage for amplifying a difference between the second filtered measured voltages and generating a single-ended measured voltage signal;

ii) a filter stage connected to the amplification stage for filtering the single-ended measured voltage signal; and,

iii) a feedback stage connected to the amplification stage for providing an integrated version of the single-ended amplified measured voltage to the amplification stage.

38. An impedance module as claimed in claim 37, wherein the interface circuitry further comprises:

a) an analog-to-digital converter connected to the processing unit for converting the single-ended measured voltage signal to create the digitized single-ended measured voltage signal;

and the programmable gain unit comprises:

b) a programmable gain amplifier including:

i) an amplification stage for amplifying the filtered single-ended measured voltage signal;

ii) a second filter stage connected to the amplification stage for filtering the output of the amplification stage; and,

iii) a variable resistance stage connected to the amplification stage for providing the plurality of gain levels, the variable resistance stage including a multiplexer and a plurality of resistor configurations connected to the output paths of the multiplexer; each

resistor configuration being related to each other by the factor K;

c) an output stage connected to the programmable gain amplifier for amplifying and shifting the DC level of the output of the second filter stage to create the single-ended amplified measured voltage.

39. An impedance module as claimed in claim 33, wherein the signal conditioning unit includes a common-mode voltage measurement stage for measuring a common-mode voltage of the received voltages, and the processing unit includes:

a) a calculator module for calculating the impedance value; and,

b) a calibrator module for correcting the calculated impedance value, the calibrator module applying a common-mode calibration step and an impedance calibration step.

40. An impedance module as claimed in claim 39, wherein, for a given calculated impedance value, the common-mode calibration step includes identifying the magnitude and phase of the measured common-mode voltage at a pre-defined measurement frequency and correcting the calculated impedance value by subtracting a weighted version of the measured common-mode voltage from the calculated impedance value, the weight being defined by the amount of common-mode voltage rejection provided by the signal conditioning unit.

41. An impedance module as claimed in claim 39, wherein, for a given calculated impedance value, the common-mode calibration step includes identifying the magnitude and phase of the measured common-mode voltage at a pre-defined measurement frequency and correcting the calculated impedance value by subtracting a common-mode calibration value from a lookup table, the common-mode calibration value being indexed by the magnitude and phase of the measured common-mode voltage.

42. An impedance module as claimed in claim 39, wherein, for a given calculated impedance value, the impedance calibration step includes correcting the calculated impedance value by applying an impedance calibration factor from a calibration table, the impedance calibration factor being indexed by the gain that is applied by the programmable gain unit, the measurement frequency and the magnitude of the calculated impedance value.

43. An impedance module as claimed in claim 42, wherein the impedance calibration factor is indexed by the phase of the calculated impedance value.

44. An impedance module as claimed in claim 39, wherein the impedance module is connectable to a calibration board for generating the calibration table, the calibration board including a plurality of calibration resistors and a plurality of calibration capacitors selectively connectable with one another to form a plurality of calibration impedances, wherein the resistance of the plurality of calibration resistors are related to one another according to $R_n=R_1*K^n$ and the capacitance of the calibration capacitors are related to one another according to $C_n=C_1*K^n$ and calibration is performed at calibration frequencies related to one another according to $F_n=F_1*K^n$.

45. A method of calculating the impedance of a body part, the method comprising:

a) providing stimulus currents for injection into the body part, the stimulus currents comprising a current signal and a complementary current signal thereby forming a differential current signal;

b) receiving voltages generated by the body part in response to the stimulus currents;

c) pre-processing the received voltages and amplifying the received voltages to generate a measured voltage signal; and,

d) calculating an impedance value based on the stimulus currents and the measured voltage signal.

46. A method as claimed in claim 45, wherein the complementary current signal is 180 degrees out of phase with respect to the current signal.

47. A method as claimed in claim 46, wherein providing the stimulus currents includes generating a first current shield signal related to the current signal for shielding the first current signal, and a second current shield signal related to the complementary current signal for shielding the complementary current signal.

48. A method as claimed in claim 47, wherein the first current shield signal is related to the first current signal by a gain factor, the gain factor being chosen to provide a negative capacitance.

49. A method as claimed in claim 47, wherein the second current shield signal is related to the complementary current signal by a gain factor, the gain factor being chosen to provide a negative capacitance.

50. A method as claimed in claim 46, wherein the frequency of the generated stimulus currents is given by $F_n=F_1*K^n$ where K is a constant and n is an integer greater than or equal to 2 and a plurality of gain levels are used for amplifying the received voltages, the gain levels being defined by $G_n=G_1*K^n$.

51. A method as claimed in claim 46, wherein the received voltages form a differential pair including a first received voltage signal and a second received voltage signal, and the method further comprises generating a first voltage shield signal related to the first received voltage signal for shielding the first received voltage signal, and generating a second voltage shield signal related for the second received voltage signal for shielding the second received voltage signal.

52. A method as claimed in claim 51, wherein the first voltage shield signal is related to the first received voltage signal by a gain factor, the gain factor being chosen to provide a negative capacitance.

53. A method as claimed in claim 51, wherein the second voltage shield signal is related to the second received voltage signal by a gain factor, the gain factor being chosen to provide a negative capacitance.

54. A method as claimed in claim 50, wherein pre-processing the received voltages includes measuring a common-mode voltage of the received voltages and calculating the impedance value includes correcting the calculated impedance value by applying a common-mode calibration step and an impedance calibration step.

55. A method as claimed in claim 54, wherein, for a given calculated impedance value, the common-mode calibration step includes identifying the magnitude and phase of the measured common-mode voltage at a pre-defined measurement frequency and correcting the calculated impedance value by subtracting a weighted version of the measured common-mode voltage from the calculated impedance value, the weight being defined by the amount of common-mode voltage rejection provided by the pre-processing step.

56. A method as claimed in claim 54, wherein, for a given calculated impedance value, the common-mode calibration step includes identifying the magnitude and phase of the measured common-mode voltage at a pre-defined measurement frequency and correcting the calculated impedance value by subtracting a common-mode calibration value obtained from a lookup table, the common-mode calibration value being indexed by the magnitude and phase of the measured common-mode voltage.

57. A method as claimed in claim 54, wherein, for a given calculated impedance value, the impedance calibration step includes correcting the calculated impedance value by applying an impedance calibration factor from a calibration table, the impedance calibration value factor being indexed by the gain level, the measurement frequency and the magnitude of the calculated impedance value.

58. A method as claimed in claim 57, wherein the impedance calibration factor is indexed by the phase of the calculated impedance value.